SIPMMEAS-M1

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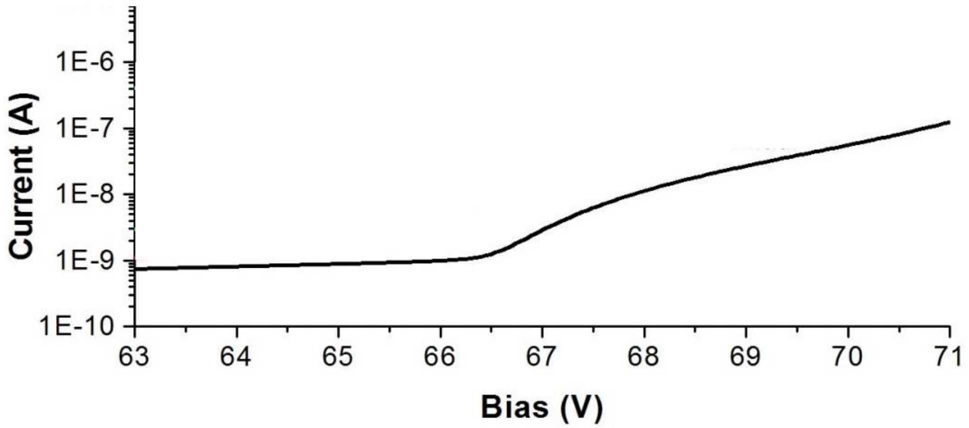
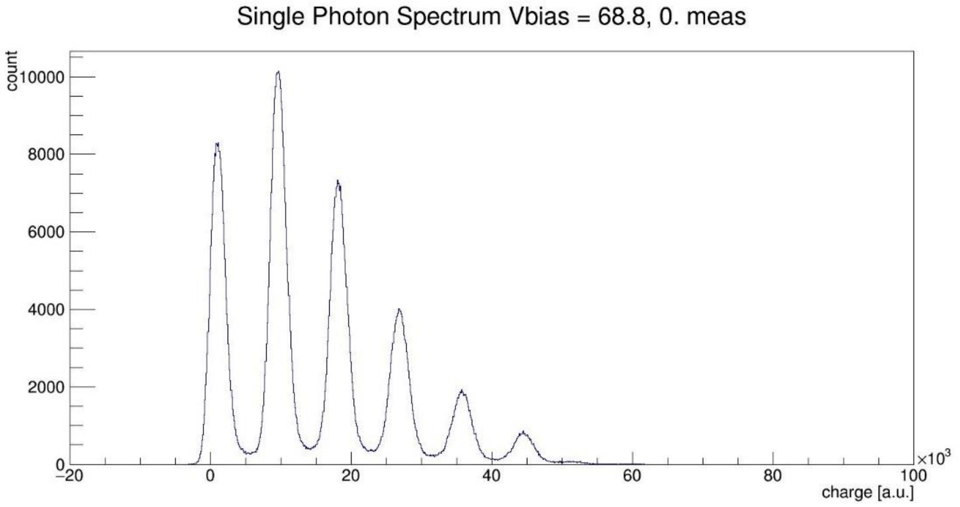
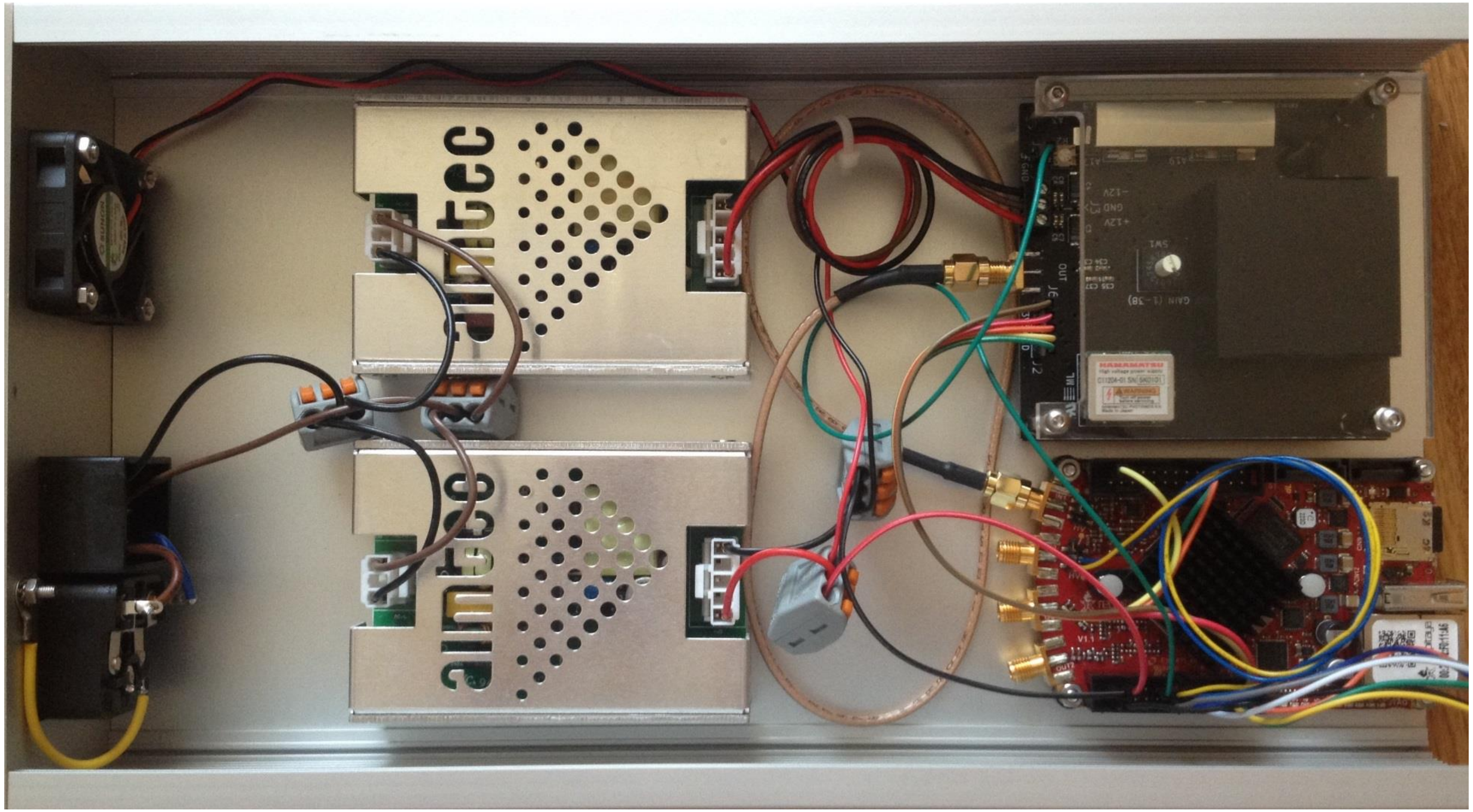
SiPM Characterization

- Goal: select SiPMs with similar response
- Two methods of characterization:
  - SPS measurement (light): gives more information (gain), but slow and does not work with irradiated SiPMs
  - I-V measurement (dark current): fast, simple, gives less information
- SIPMMEAS-M1 is designed for SPS measurement (upgrade is coming soon)



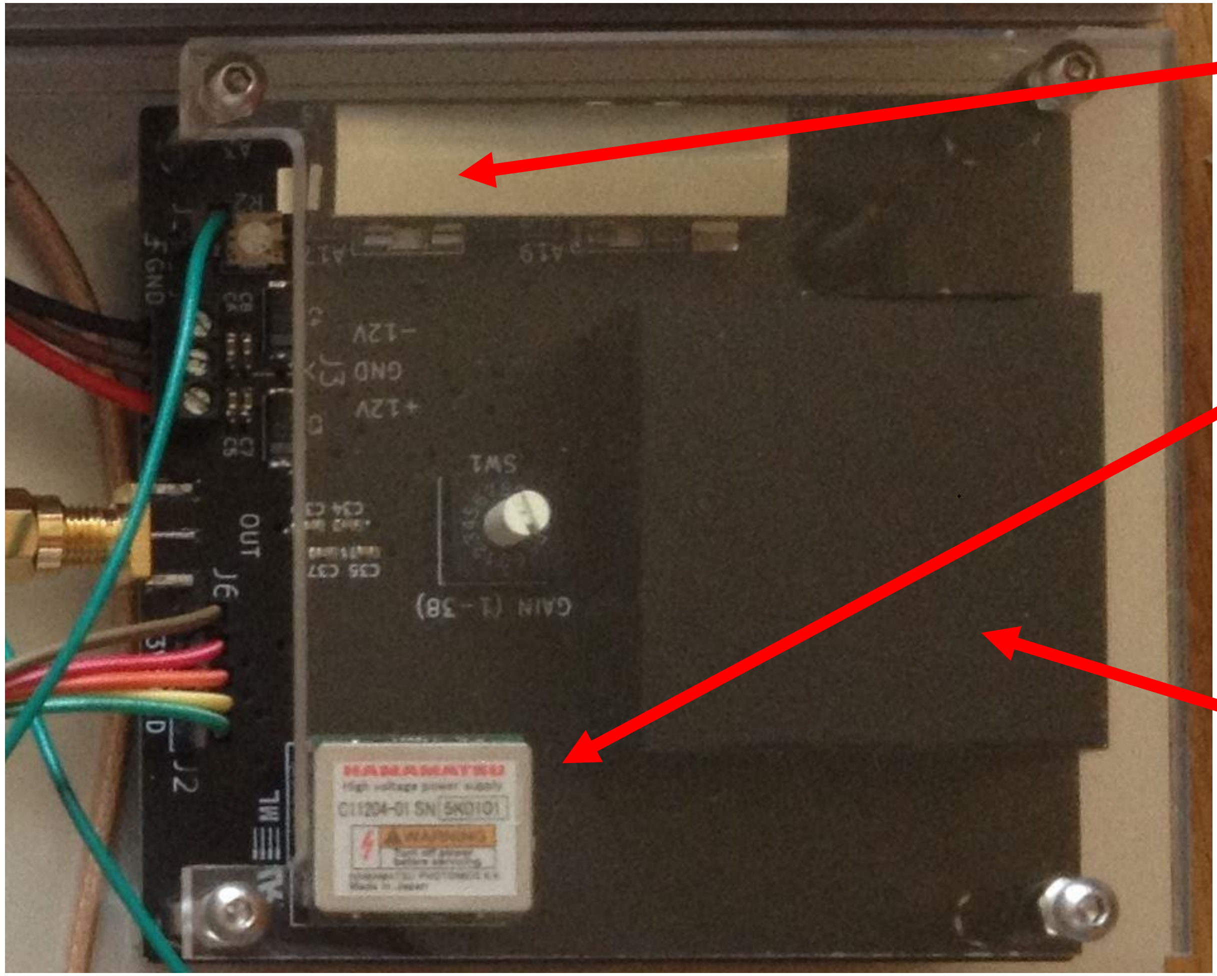


What is inside?

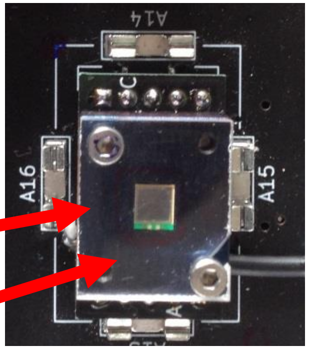


- Dual output (+/-12V) power supply for the analog parts
- Single output (5V) power supply for the digital parts (RedPitaya board)
- Analog PCB
- RedPitaya board

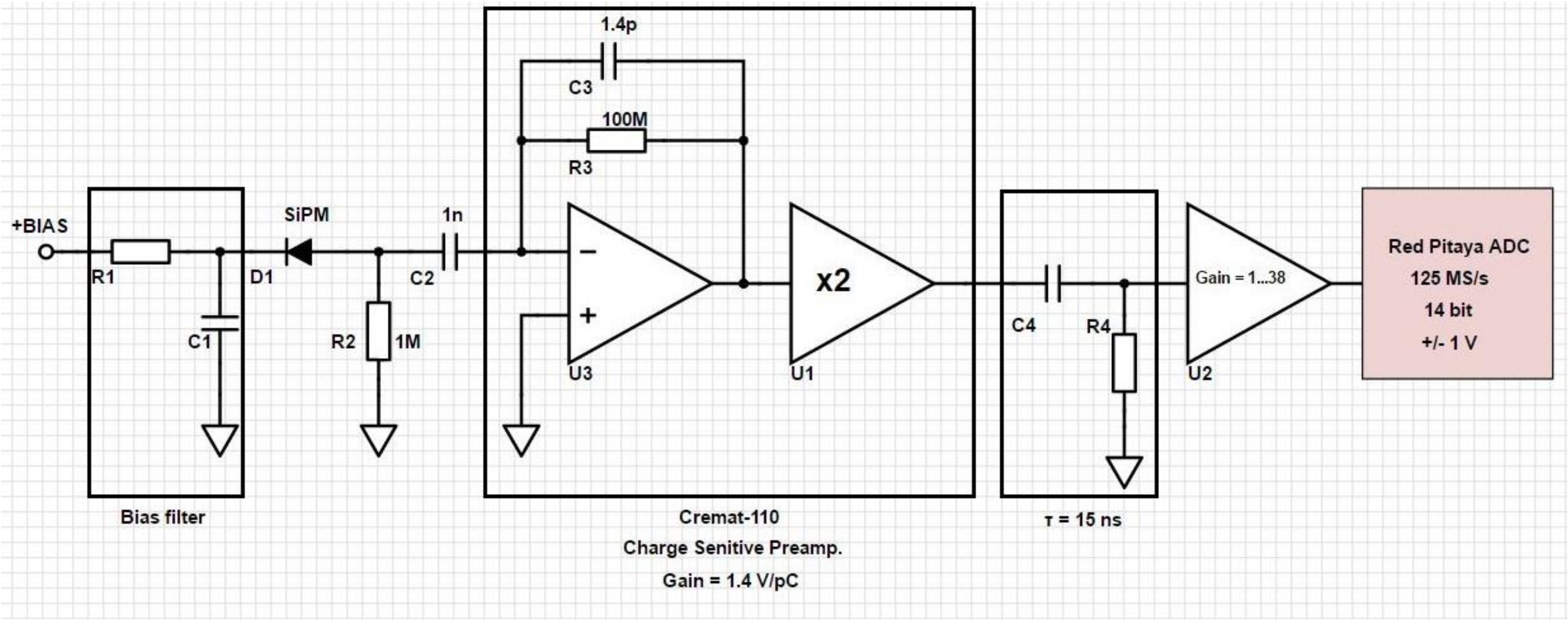
Analog PCB



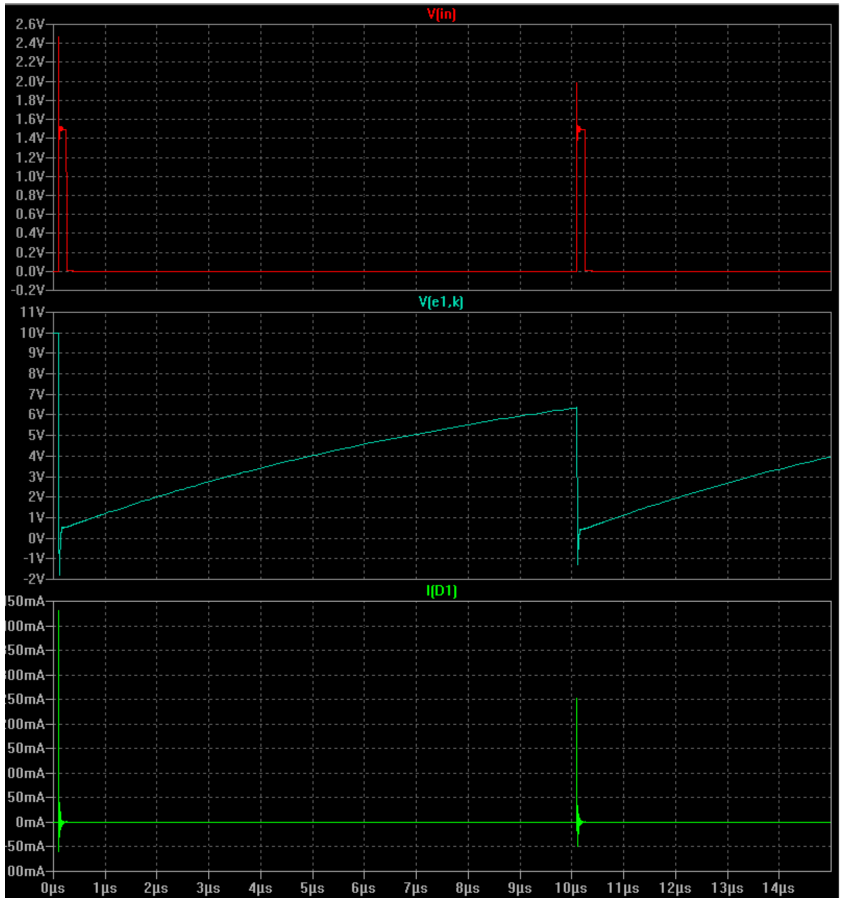
- Kapustinsky LED pulser, optically coupled to the SiPM (through optical fiber)
- Hamamatsu C11204-01 HV PSU to provide bias voltage
- Amplifers (next slide)
- Temperature sensor
- SiPM socket (under reflective and light-tight cover))

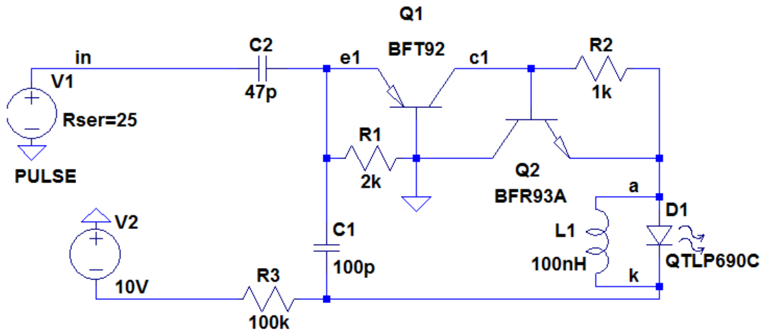


Analog schematic



Kapustinsky LED pulser





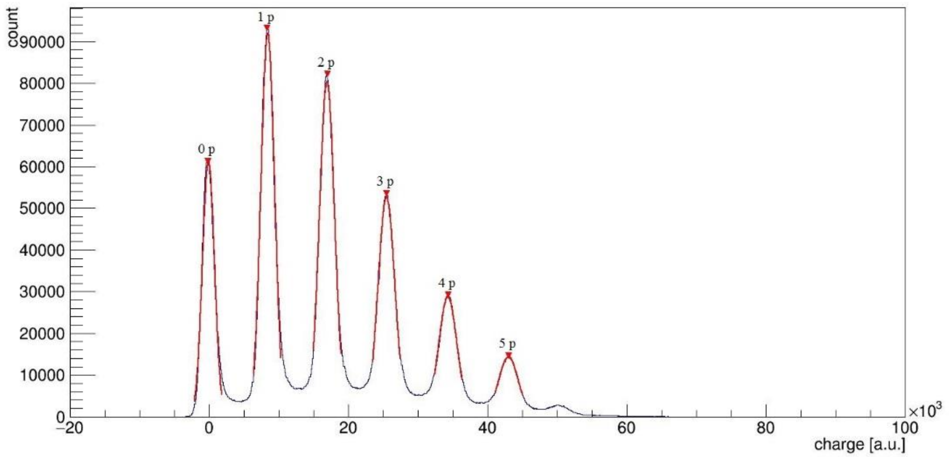
- Principle: discharging C1 through the LED -> light pulse (1-2 ns FWHM)
- Trigger: rising edge on V1 input (controlled by RedPitaya)
- Light yield is controlled via trigger rate (C1 charges through R3, time constant is 10 µs)

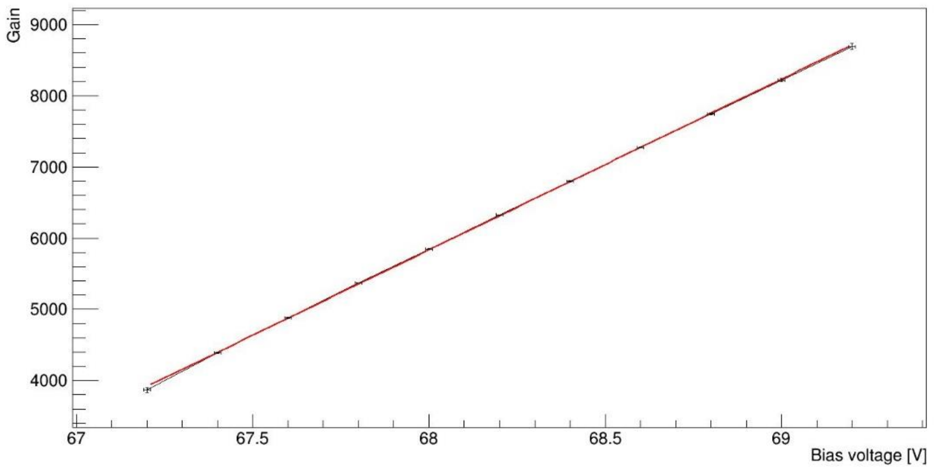
RedPitaya

- Two 125 Msps ADCs on board
- Xilinx ZC7Z010 SoC (dual core Cortex-9 ARM processor + FPGA)
- FPGA: triggers LED, sums up ADC samples in a specified time window, stores the result in FIFO buffer
- ARM processor: runs an embedded Linux operating system and custom applications (for sending data, receiving commands through Ethernet network)

Client side

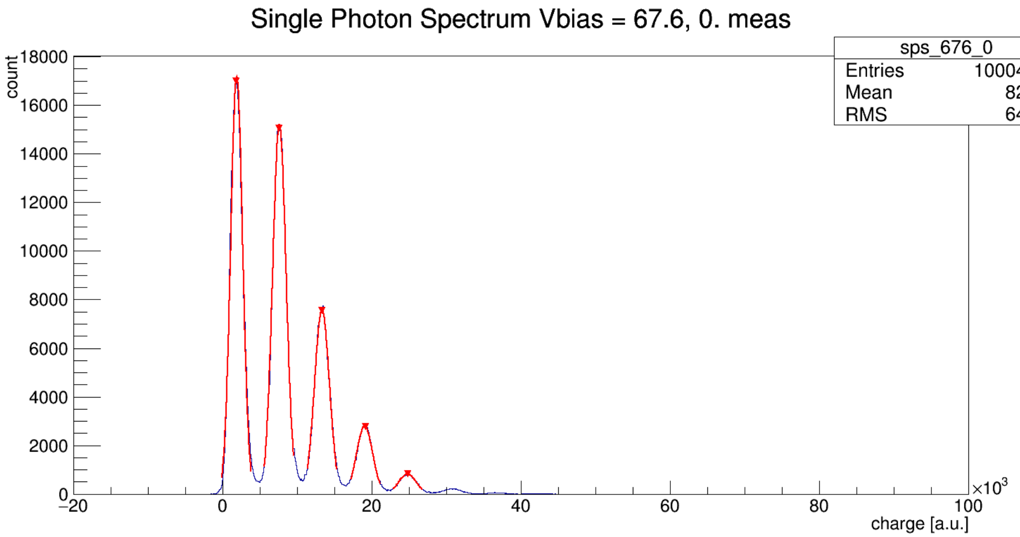
- Data processing application, developed in ROOT
- Able to set bias voltage, get temperature, set FPGA registers (integration window, restart cycle (explicitly light yield))
- Receives measurement data, draws SPS spectra, fits Gaussian functions, determines breakdown voltage

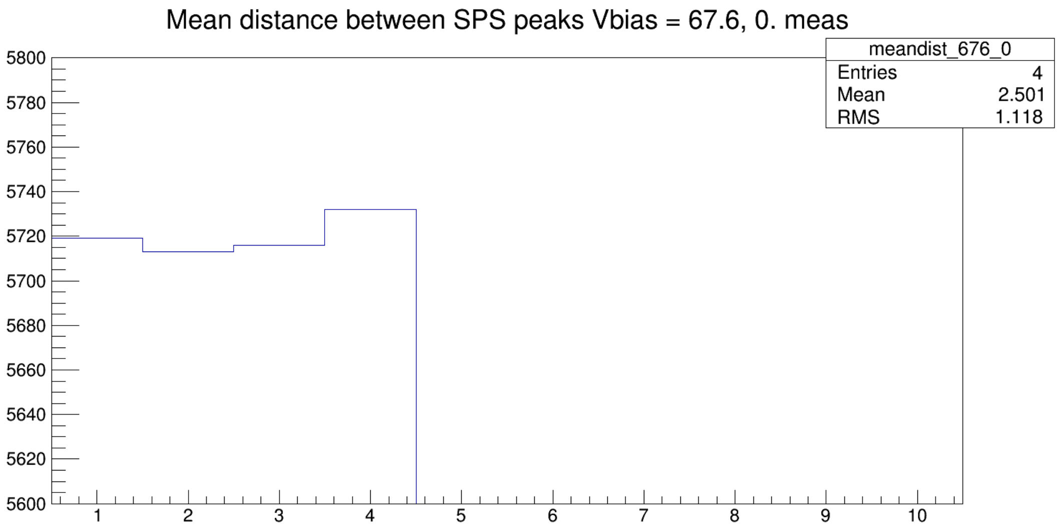




Calculating gain and uncertainty

- More methods:
  - Using more distances (between 0-1 pe, 1-2 pe, 2-3 pe peaks), calculating average and deviation
  - E.g.: Using first 3 distances. Avg(distance) $\approx$ 5716, $\mathrm{D(distance)} \approx 3, \rightarrow G \approx 5716 \pm 3$

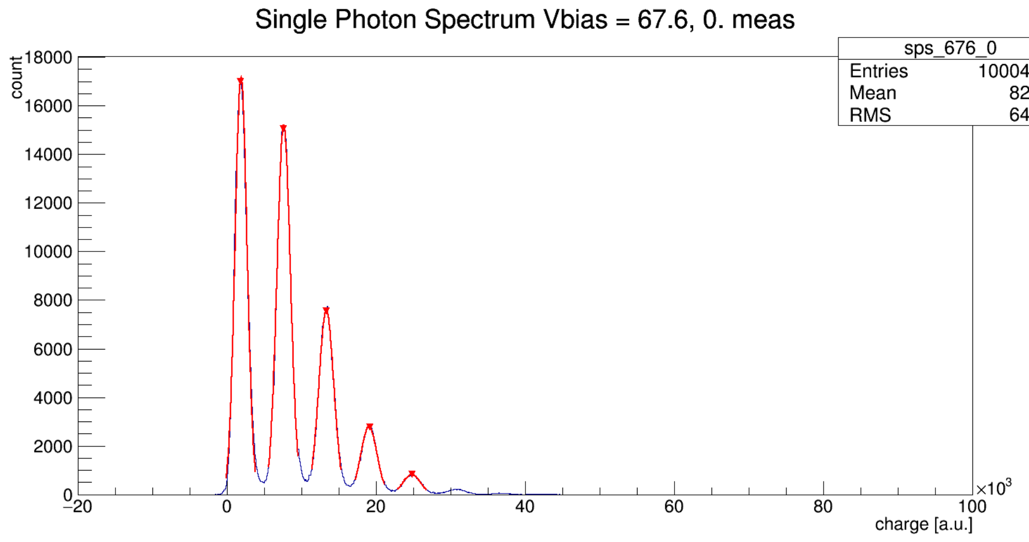


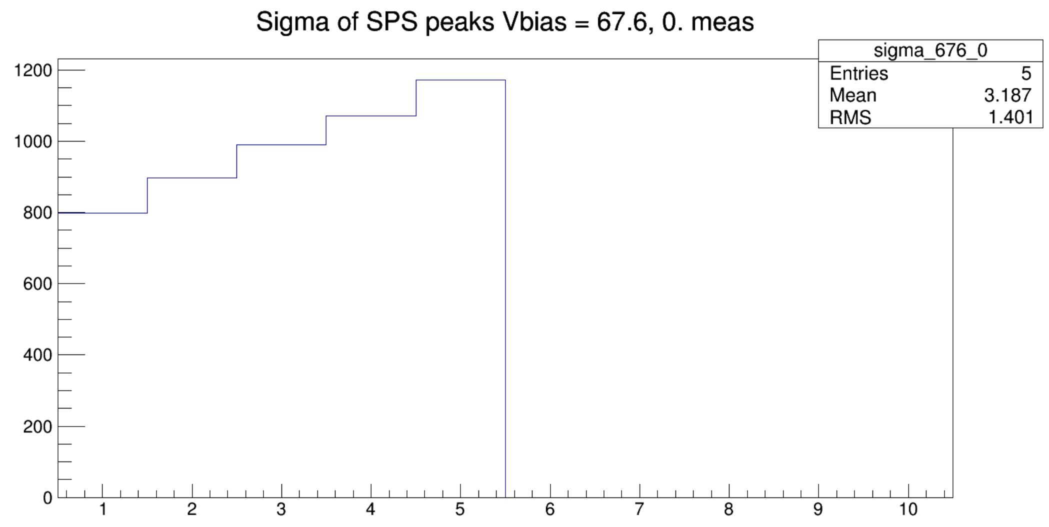


Calculating gain and uncertainty

- More methods:
  - Using only the distance between 1 pe and 2 pe peaks, uncertainty is $\sigma = \sqrt{\sigma_1^2 + \sigma_2^2}$

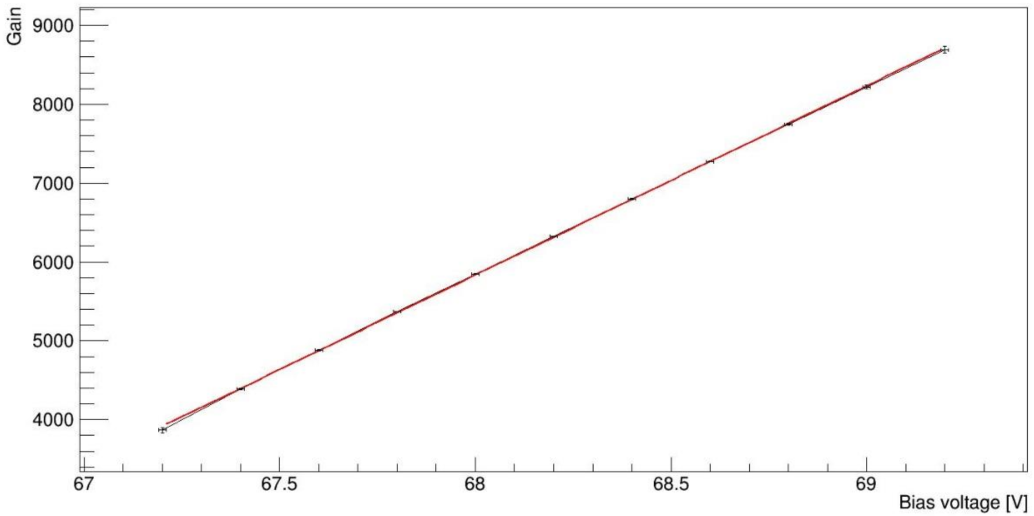
  (Gerald Eigen, arXiv: 1603.00016v1 [physics.ins-det] (2016))





Determining breakdown voltage

- Gains at different bias voltages are filled into a graph
- Breakdown voltage is determined by extrapolating to zero gain using a linear fit
- Result: 65.53 V @ 30.6 ℃, 65.19 V @ 25 ℃ (temperature coefficient is 60 mV/℃), 0.37 V higher than the value given by Hamamatsu



- Uncertainty (more methods):
  - Propagation of uncertainty from fit parameter errors: +/- 0.69 V
  - Doing more independent measurements and calculating deviation: +/- 0.005V